

CLAIMS

1. A direct-current motor, comprising;
an armature core, wherein the core has a plurality of
5 teeth, the teeth being arranged at a pitch of a first
predetermined angle;
a plurality of armature coils, wherein each coil is wound
about a different group of teeth having a predetermined number
of teeth, wherein each tooth is located at the most advancing
10 position in the rotation direction in one of the teeth groups,
and wherein the armature core and the armature coils form an
armature;
a plurality of magnets, wherein the magnets face one
another with the armature in between, wherein each magnet
15 includes:
a main portion;
an extended portion extending from the main
portion;
a first weak flux part, which is located in the
20 vicinity of the border of the extended portion and the
main portion, wherein the first weak flux part extends
along one pitch of the teeth, and the flux of the first
weak flux part gradually increases along the rotation
direction of the armature;
25 a commutator, which has a plurality of segments, wherein
the segments are connected to each coil;
a pair of brushes, which can contact each segment,
wherein the brushes supply current to the coils through the
segments, wherein, during commutation, each brush establishes
30 a short circuit in an adjacent pair of the commutator
segments, thereby changing the direction of current flowing
through the coil; and
wherein, when commutation is started for a group of
teeth, the advancing end of the first tooth in that teeth
35 group, the first tooth being located at the most advanced

position in the group in the rotation direction of the armature, is aligned with the first weak flux part of one of the magnets.

5 2. The direct-current motor according to claim 1, wherein the number of teeth belonging to the same group is represented by n , wherein the circumferential length of the main portion of each magnet corresponds to a second predetermined angle, wherein the second predetermined angle is determined such
10 that, when the circumferential center of the first tooth is aligned with the most advancing portion of the main portion in the rotation direction of the armature, the most trailing end of the main portion in the rotation direction of the armature is circumferentially located between the n th tooth and $(n-1)$ th
15 tooth.

3. The direct-current motor according to claim 1, wherein the main portion of each magnet includes a second weak flux part, wherein the second weak flux part is spaced from the
20 first weak flux part by an angle that corresponds to the first predetermined angle multiplied by an integer, and wherein the flux of the second weak flux part increases in a direction opposite to the rotation direction of the armature.

25 4. The direct-current motor according to claim 3, wherein the second weak flux part comprises a plurality of second weak flux parts, and wherein the second weak flux parts are located in the main portion of each magnet.

30 5. The direct-current motor according to claim 3, wherein the first weak flux part and the second weak flux part are formed by removing part of the inner surface of the main portion of each magnet.

35 6. The direct-current motor according to claim 5, wherein

the volume of part removed for forming the second weak flux part is equal to the volume of part removed for forming the first weak flux part.

5 7. The direct-current motor according to claim 1, wherein
the number of teeth belonging to the same group is represented
by n , wherein the circumferential length of the main portion
of each magnet corresponds to a second predetermined angle,
wherein the second predetermined angle is determined such
10 that, when the circumferential center of the first tooth is
aligned with the most advancing portion of the main portion in
the rotation direction of the armature, the most trailing end
of the main portion in the rotation direction of the armature
is aligned with the advancing end of the n th tooth in the
15 rotation direction of the armature.

20 8. The direct-current motor according claim 1, wherein the
number of teeth belonging to the same group is represented by
 n , wherein the circumferential length of the main portion of
each magnet corresponds to a second predetermined angle,
wherein the second predetermined angle is determined such
that, when the circumferential center of the first tooth is
aligned with the most advancing portion of the main portion in
the rotation direction of the armature, the most trailing end
25 of the main portion in the rotation direction of the armature
is aligned with the trailing end of the $(n-1)$ th tooth in the
rotation direction of the armature.

30 9. The direct-current motor according to claim 1, wherein
the pitch of the segments is equal to the pitch of the teeth,
and wherein an angle that corresponds to the contacting width
between each brush and each segment is equal to the pitch of
the teeth.

35 10. The direct-current motor according to claim 1, wherein

the number of the magnets is two, and wherein the magnets are symmetric with respect to the axis of the armature.

11. The direct-current motor according to claim 1, wherein
5 the first weak flux part is formed by removing part of the outer surface of the main portion of each magnet.

12. A direct-current motor, comprising;
an armature core, wherein the core has a plurality of
10 teeth, the teeth being arranged at a pitch of a first predetermined angle;

a plurality of armature coils, wherein each coil is wound about a different group of teeth having a predetermined number of teeth, wherein each tooth is located at the most advancing
15 position in the rotation direction in one of the teeth groups, and wherein the armature core and the armature coils form an armature;

a plurality of magnets, wherein the magnets face one another with the armature in between, wherein each magnet
20 includes:

a main portion;
an extended portion extending from the main portion;

a first weak flux part, which is located in the vicinity of the border of the extended portion and the
25 main portion, wherein the first weak flux part extends along one pitch of the teeth, and the flux of the first weak flux part gradually increases along the rotation direction of the armature;

a commutator, which has a plurality of segments, wherein
30 the segments are connected to each coil;

a pair of brushes, which can contact each segment, wherein the brushes supply current to the coils through the segments, wherein, during commutation, each brush establishes
35 a short circuit in an adjacent pair of the commutator

segments, thereby changing the direction of current flowing through the coil; and

wherein the number of teeth belonging to the same group is represented by n , and wherein the position of each brush is determined such that, when the first tooth in one of the teeth groups, the first tooth being located at the most advanced position in the group in the rotation direction of the armature, is aligned with the first weak flux part of one of the magnets, the brush starts establishing a short circuit in an adjacent pair of segments that connects the coil.

13. A direct-current motor, comprising;

an armature core, wherein the core has a plurality of teeth, the teeth being arranged at a pitch of a first predetermined angle;

a plurality of armature coils, wherein each coil is wound about a different group of teeth having a predetermined number of teeth, wherein each tooth is located at the most advancing position in the rotation direction in one of the teeth groups, and wherein the armature core and the armature coils form an armature;

a pair of magnets, wherein the magnets face each other with the armature in between, wherein each magnet includes:

a main portion, wherein the circumferential length of the main portion corresponds to a second predetermined angle, wherein the number of teeth belonging to the same group is represented by n , and wherein, when the circumferential center of the first tooth in the group is aligned with the most advancing portion of the main portion in the rotation direction of the armature, the most trailing end of the main portion in the rotation direction of the armature is circumferentially located between the n th tooth and $(n-1)$ th tooth;

an extended portion extending from the main portion;

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a first weak flux part, which is located in the vicinity of the border of the extended portion and the main portion, wherein the first weak flux part extends along one pitch of the teeth, and the flux of the first weak flux part gradually increases along the rotation direction of the armature;

5 a commutator, which has a plurality of segments, wherein the segments are connected to each coil;

10 a pair of brushes, which can contact each segment, wherein the brushes supply current to the coils through the segments, wherein, during commutation, each brush establishes a short circuit in an adjacent pair of the commutator segments, thereby changing the direction of current flowing through the coil; and

15 wherein, when commutation is started for a group of teeth, the advancing end of the first tooth in that teeth group is aligned with the first weak flux part of one of the magnets.

20 14. The direct-current motor according to claim 13, wherein the main portion of each magnet includes a second weak flux part, wherein the second weak flux part is spaced from the first weak flux part by an angle that corresponds to the first predetermined angle multiplied by an integer, and wherein the flux of the second weak flux part increases in a direction opposite to the rotation direction of the armature.

30 15. The direct-current motor according to claim 14, wherein the second weak flux part comprises a plurality of second weak flux parts, and wherein the second weak flux parts are located in the main portion of each magnet.

35 16. The direct-current motor according to claim 15, wherein the first weak flux part and the second weak flux part are formed by removing part of the inner surface of the main

portion of each magnet.

17. The direct-current motor according to claim 13, wherein
the pitch of the segments is equal to the pitch of the teeth,
5 and wherein an angle that corresponds to the contacting width
between each brush and each segment is equal to the pitch of
the teeth.

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